What Motivates Introductory Geology Students to Study for an Exam?

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ABSTRACT

There is a need to understand why some students succeed and persist in STEM fields and others do not. While numerous studies have focused on the positive results of using empirically validated teaching methods in introductory science, technology, engineering, and math (STEM) courses, little data has been collected about the student experience in STEM courses. The aim of this study was to capture and characterize the student perception of their motivation to study for an exam in a geoscience class. Students enrolled in introductory physical geology courses ($n = 42$) at 5 different institutions (seven instructors at two research universities and three community colleges) were interviewed using a semistructured protocol. The interview data were analyzed using a grounded theory approach. The resulting emergent themes included goal orientation and emotion. All students report a performance component to their motivation, where a learning task is a means to an end, such as earning a grade. However, most high performing students (70%) also reported their motivation was also oriented towards a mastery goal, where a learning task itself serves as an end, such as satisfying curiosity, more frequently than low performing students (18%). The majority of students (81%) also described an emotional component to their motivation. Contrary to existing models, most students indicated they were motivated to engage in exam preparation as a way to avoid experiencing negative emotions. These resulting insights to student motivation have implications both for course design and instructional practices in similar introductory courses. © *2014 National Association of Geoscience Teachers*. [DOI: 10.5408/13-110.1]

Key words: affect, motivation, undergraduates, learning strategies, community college, emotion, learning outcomes, self-regulated learning

INTRODUCTION

The United States is facing a STEM (Science, Technology, Engineering, and Math) workforce shortage (President's Council of Advisors on Science and Technology [PCAST], 2012). Nearly half of college-level STEM majors switch to nonmajors within the first two years of their college experience (Strenta et al., 1994; Seymour and Hewitt, 1997). Much of this workforce demand can be met if we can reduce the STEM attrition rate by just 10% (PCAST, 2012). It is therefore important to understand why students are leaving STEM fields like geology, so that intentional changes can be made to improve retention.

Why are students leaving STEM? Many students identify dissatisfaction with their introductory STEM classes as a primary factor in their leaving STEM (Tobias, 1990; Seymour and Hewitt, 1997). In other words, if a student with a geology major takes an introductory geology course and has a negative experience, they are likely to change majors and leave STEM altogether. In addition, student experiences in introductory geology courses have been identified as critical gateway for attracting geology majors (Levine, 2007; Houlton, 2010; Wilson, 2013). Compared to other STEM fields, the student experience in college level introductory geology courses is doubly important, not only for retaining existing majors, but also for attracting new students to the discipline.

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Before the student experience can be improved, we need to first establish a baseline for the features of that experience. There has been a notable body of work in discipline-based education research in the STEM fields over the last 30 years (National Research Council [NRC], 2012) that has focused on student cognition (e.g., teaching practices and learning gains, metacognition) but less attention has been paid to student affect (NRC, 2012). Research on the affective domain of the student experience (e.g., emotions, attitudes, motivation, values) is gaining recognition for its critical role in student engagement and is emerging as a key area of interest in the field (van der Hoeven Kraft et al., 2011; NRC, 2012). This study is part of the large-scale collaborative efforts of the Geoscience Affective Research Network (GARNET), which aims to measure affect among students in introductory geology courses across the United States (Gilbert et al., 2012). In this study we explore and characterize what motivates university and community college students to prepare for an exam in an introductory geology course. We report the results of a series of student interviews that investigate some aspects of student motivation associated with exam preparation in introductory geology courses. Further, we discuss the importance of student emotion as an additional driver of study behaviors.

Why is it Important to Understand Student Motivation?

What do we mean by motivation? While there is much debate surrounding the definition and nature of motivation, here we define motivation as a "process whereby goal-directed activities are instigated and sustained" (Schunk et al., 2013, 5). In other words, motivation is an excited internal state that involves the beliefs and/or emotions that someone holds and results in strategy use and behaviors that aim to avoid or seek something. Some students may arrive at this

state driven by factors such as an interest in the topic, by a sense of academic self-preservation, and/or through the encouragement of family, peers, and/or the instructor. Others will struggle to develop motivation in some educational environments and this will hamper their efforts to achieve learning goals. Whatever the cause, motivation, both in and out of the classroom, is critical to student learning in any domain including the geosciences (van der Hoeven Kraft et al., 2011). Models of student learning (e.g., Pintrich and Zusho, 2007) indicate that motivational processes drive student action, such as studying for an exam, and can positively mediate learning outcomes (e.g., achievement, persistence, effort; McConnell and van der Hoeven Kraft, 2011).

What Do We Already Know About Student Motivation?

There are several theories and approaches linking student motivation and learning. The diversity in models speaks to the complexity of motivational processes. Data that emerged from this study was consistent with one of these theoretical frameworks, achievement goal theory, which is discussed below. For a more thorough review of motivational theory, the reader is directed to Schunk et al. (2013), which provides a comprehensive discussion and analysis of motivational theory as applied to education research.

A student's goal orientation refers to "an integrated pattern of beliefs, attributions, and affect that produces the intentions of behavior" (Weiner, 1986; quoted in Ames, 1992, 261). In other words, goal orientations are the rationale for *why* a student pursues an achievement task (Schunk et al., 2013) rather than the performance objective a student has for an achievement task (e.g., earn a grade of X on an exam; Kaplan and Maehr, 2007). Goal orientation is expressed and observed in the different ways students approach, engage in, and respond to achievement tasks (Ames, 1992; Dweck and Leggett, 1988). While there are many different models of goal orientation, there is general consensus in the literature (Schunk et al., 2013) that there are two main goal orientations: performance goal orientation and mastery goal orientation. A student with a performance orientation engages in learning activities with the purpose of demonstrating competence or ability, often in a context of how that achievement will be judged relative to others (Schunk et al., 2013). Engagement in a task is viewed as a means to an end, such as rewards, which in academic settings are often (course) grades (Pintrich et al., 1993). In contrast, a student with a mastery goal orientation, sees the task as an end itself (Pintrich et al., 1993) and thus engages with the purpose of self-improvement by developing new skills, acquiring new knowledge, and/or improving competence by overcoming a challenge (Schunk et al., 2013). For example, a geology major might seek to be successful in a course to enhance their GPA so that he or she can earn a place in graduate school (performance orientation) but he or she can also recognize that they are developing a skill that will be applied in their career (mastery orientation). Some have suggested that students may toggle between multiple goals, each with their own type of orientation (Pintrich, 2000b).

Goal orientation is typically measured through self-report surveys, like the Motivated Strategies for Learning Questionnaire (MSLQ; Pintrich et al., 1993) in which students use a Likert scale (e.g., 1 = strongly disagree to 7 = strongly agree) to rate their reaction to a statement describing a manifestation of a person's goal orientation (e.g., "I want to do well in this class because it is important to show my ability to my family, friends, employer, and others." Or "I prefer course material that challenges me to learn new things."). These ratings for statements associated with each goal orientation (performance or mastery) are usually then averaged to create an overall goal orientation score (e.g., Gilbert et al., 2012).

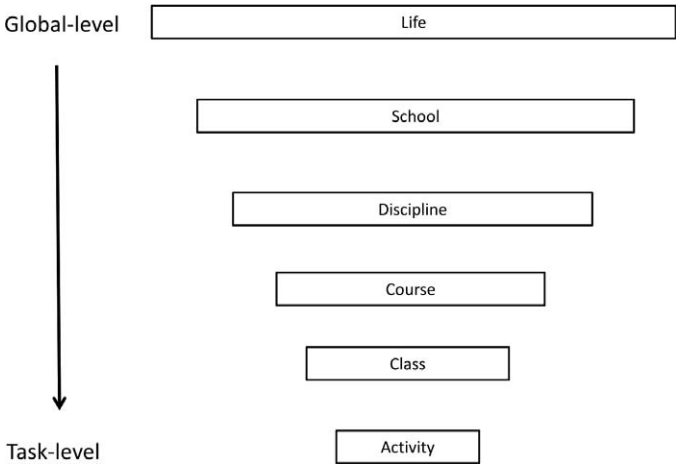

FIGURE 1: There are different levels of motivation that influence student engagement. Students may be motivated at a more global level one moment, such as engaging in school in general to a more task level another moment, such as completing a homework assignment. Students may toggle between these levels when asked to describe their motivation for a specific example of one of these motivational levels.

Goal orientations have also been linked to emotion through correlational studies (Linnenbrink and Pintrich, 2002; Pekrun et al., 2002). Mastery goals have been reported to be predictors of enjoyment of learning, hope, and pride whereas performance-avoidance goals have been described as predictors of anxiety, hopelessness and shame (Pekrun et al., 2006). These studies tend to view emotions as outcomes rather than part of the motivational process itself. For example, performance goal-oriented students feeling more anxiety and shame after poor performance and mastery goal-oriented students feeling more pride after achievement. These studies do not explicitly define the role emotions play in motivational processes as they are correlational in nature and causation cannot be established from the data.

It is important to remember that there are different levels of motivation when discussing motivation in a formal learning context such as an introductory geology course (Fig. 1). A person may be motivated to engage at a global level such as engagement in school in general. They be motivated at the discipline level, in this case their engagement in science. A student may be motivated at the course level as seen by their engagement in the geology course as a whole and/or at the class level, such as their engagement in a specific day or week of class. Finally, a student can be motivated at the task level through their engagement in activities like responding to a clicker question, completing homework, or studying for an exam. In addition to a student potentially alternating between multiple goals, they are

likely to also be toggling between different levels of motivation. For example, in a geology class, a student's motivation may be oriented towards performance because they want to earn a good grade on the exam (task-level) because they want to earn a good grade in the class (course-level), so that they will complete the credits necessary to earn a college degree (school-level; Fig. 1). In research, therefore, it can be difficult to sort out those differences and influences. Self-report instruments such as the MSLQ (Pintrich et al., 1991) capture the course level motivation of a student, but may miss the day-to-day connection between student motivation and action. For the purposes of this study, we have chosen to focus on the task-level motivation of students, specifically their motivation to prepare, or study, for an exam. By asking students to reflect on their motivation to study for an exam rather than their motivation in the course as a whole, we can gain insights into how student motivation directly connects to specific choices and actions of students in an introductory geology course. These insights have the potential to inform instructor practice in terms of what resources and scaffolding methods would be most beneficial to students.

Research Question and Goals

This study sought to answer the question: What motivates students to study for an exam (task-level motivation)? Specifically, in this article, we seek to answer the following questions: Are there differences in the goal orientation of high and low performing students as they prepare for an exam? What role do emotions play in student motivation to study for an exam? Are there any differences between research university and community college populations? In addition to addressing these questions, a broader goal of this study was to identify the implications of this motivation as it relates to instructor practice.

METHODS

Motivation is often inferred through the product of student actions rather than measured directly (e.g., if Sally earns an A, then Sally is said to be motivated). A better proxy for understanding motivation as a process is by asking students to reflect on the rationale behind their goals, choices, and actions. This study takes a qualitative approach to investigate student motivation through interviews that evoke student reflection. As a methodological framework, a qualitative approach yields richer descriptions and captures contextual relationships that are inherently omitted by quantitative methods (e.g., surveys).

Data Collection

A total of 73 students, from two research universities (R1) and three community colleges (2YC), volunteered to be interviewed as part of a larger study (e.g., Gilbert et al., 2012). The university classes typically enrolled 80–150 students each, whereas, the community college classes enrolled fewer than 50 students. University students were interviewed between weeks 10 and 12 of the semester (students had taken two exams prior to interview). All of the community college students were interviewed between weeks 8 and 9 of the semester after completing one or two exams, with the exception of students from one community college class who were interviewed during week 5—the week before their first exam.

Student interviews were conducted in person (by the first author) and lasted 15–75 minutes depending on the extent of student responses. During the interview, students were asked a consistent suite of questions about their experiences in their introductory geology course, with a particular focus on how students study for and prepare for an exam in the course through questions such as "What motivates you to do what you just described [about how you study for an exam]?" (The complete list of questions and interview protocol are described in Appendix A in the supplementary materials, which can be found online at http://dx.doi.org/10.5408/13-110s1). Following a grounded theory approach to the study (Oktay, 2012; illustrated in Phase 1, shown in Fig. 2), the interviews were semi-structured in nature, providing students with open-ended questions that allowed student-identified themes to emerge and be further investigated by the interviewer with follow-up questions. Interviews were digitally recorded and later transcribed. Upon completion of the interview, participants reviewed the interviewer's notes to confirm accuracy. After the interview, the interviewer created memos: summarizing nonverbal observations of the students and interviewer reactions and impressions, identifying emerging ideas and themes, and comparing interview notes and memos to data in previous interviews and memos (the constant comparison component of grounded theory methods).

Participants

A grounded theory approach is an iterative, recursive process that relies on constant comparison. Consequently, the interview protocol developed over time through 73 student interviews. To ensure consistency, the participants included in this study are the 42 students that were interviewed with the final version of the protocol. From the larger study survey data, participants were nearly evenly split between sex (55% female) and between research university and community college (55% R1). In terms of diversity, 21% indicated they were of a background other than white (non-Hispanic) and 19% did not disclose ethnicity/race. In terms of age, the majority of participants reported they were of traditional age, with 19% reporting they were nontraditional in age (25 or older). More than two thirds (69%) indicated that were "very interested" or "somewhat interested" in science, but only 21% indicated that they were "very likely" or "somewhat likely" to be a science major. In terms of achievement, while 70% of students earned an A or B in the class at the end of the semester, only 48% earned an A or B average on exams/quizzes.

When divided into research university and community college subpopulations, participants were nearly evenly split between sex (58% female for community college and 52% for research university). Community college students were notably nontraditional in age, with 37% reporting they were 25 or older.

Qualitative Analysis

Following a standard grounded theory approach to analyzing the interview data (Charmaz and Belgrave, 2012; Fig. 2), transcribed interviews were read in an iterative, recursive fashion, allowing the researcher to constantly compare data between interviews. Prior to coding, all 42 interviews and their corresponding memos were read by the

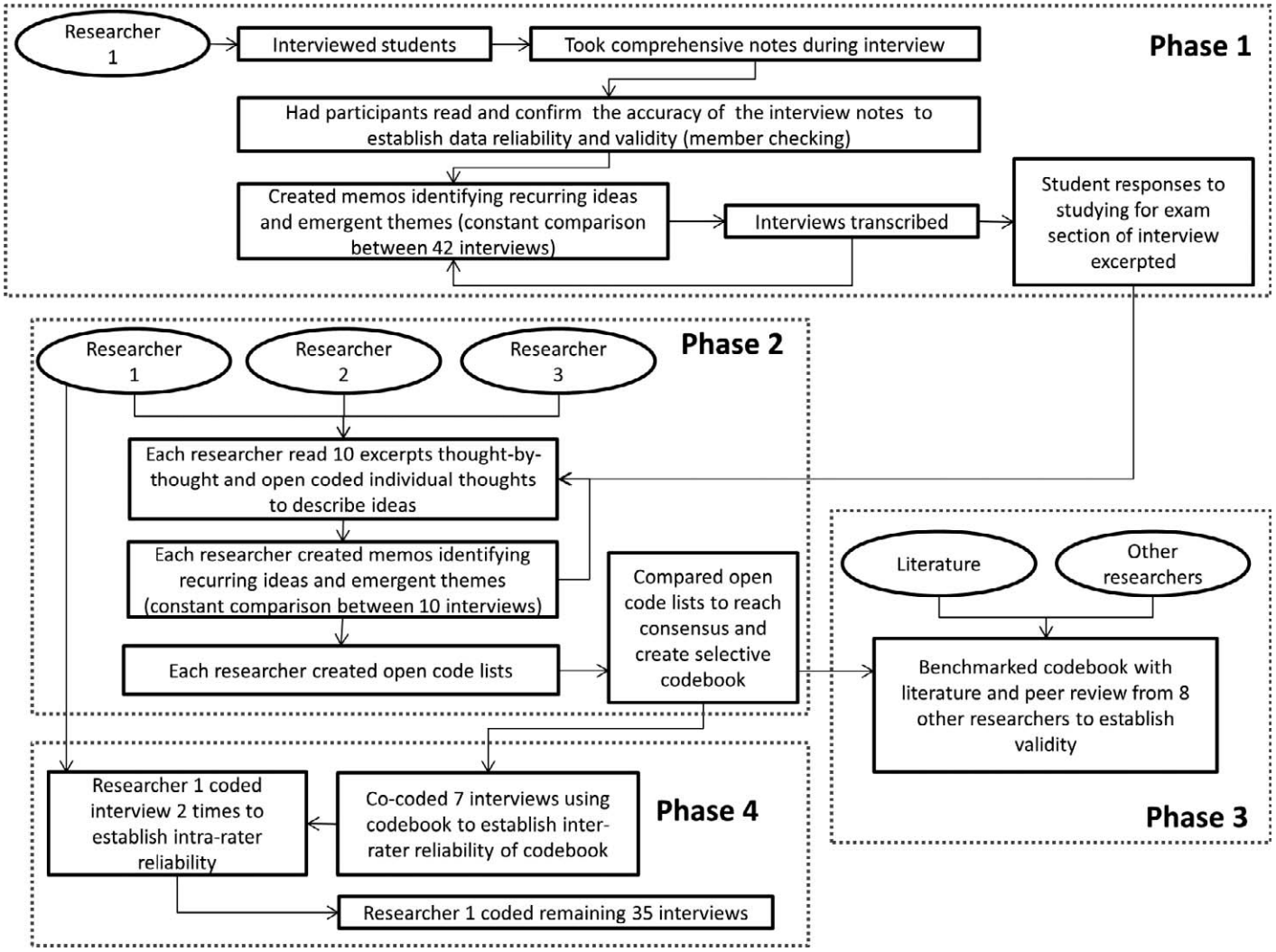

FIGURE 2: The qualitative method process is depicted in four major phases. Phase 1 describes the data collection process. Phase 2 describes the analysis process, codebook creation, and the first stage of codebook validation. Phase 3 describes the external validation process for the codebook. Phase 4 describes the reliability process and final data analysis process.

primary investigator to identify recurring ideas and emergent themes. Interviews were then coded following common practices to ensure trustworthiness. First (Phase 2 in Fig. 2), during open coding, 10 transcripts were dissected by the primary investigator and two other researchers (one involved in the larger GARNET investigation and one unfamiliar with the project) at the individual thought level, meaning that each separate thought a student had about a source of motivation was tagged. For example, "I want to pass . . . plus, I'm a science major, so I want to know this stuff." would be split into two separate tagged items ("I want to pass" and "I'm a science major, so I want to know this stuff."). Next, memos were created to identify recurring ideas and initial interpretations. From the memos, a list of open codes was compiled and revised in a recursive manner as the interview transcripts were analyzed. The primary investigator coded and recoded each interview three times in an effort to test–retest the codes to establish intracoder reliability. The open codebooks, open coding results, and memos between researchers were compared to establish interrater reliability and validity through peer review. These emergent results were also compared to the dominant motivation in education literature to identify any overlap (Phase 3 in Fig. 2). Consensus between researchers was reached on recurring ideas and themes for a final codebook (see Table I) to be used for selective coding. Interview transcripts were recoded (Phase 4 in Fig. 2) using the final codebook (each transcript recoded twice by the primary investigator to establish 100% intrarater reliability). Interrater coding reliability (in this case, percent of agreement) was established through the cocoding methods of Gorden (1992). The two coders reached an initial average agreement of 92% (using 7 of the 10 interviews), reaching 100% consensus on all seven interviews through discussion. The remaining interviews were then coded by the primary investigator. These selective coding results and resulting memos were synthesized to develop categories: performance goal orientation, mastery goal orientation, avoiding negative emotion(s), and approaching positive emotion(s). Eventually, an emergent model of student motivation in studying for an exam in an introductory

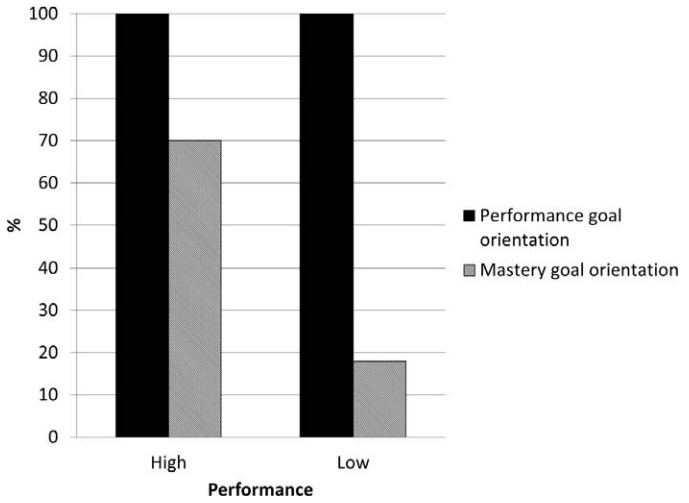

FIGURE 3: Percent of high performers (earned A or B average on exams; $n = 20$) and low performers (earned a C or below average on exams; $n = 22$) who reported aspects of performance (e.g., extrinsic rewards like grades and what grades could get them like degree, job, etc.) and mastery (e.g., desire to learn, interest, future value, etc.) goal orientations.

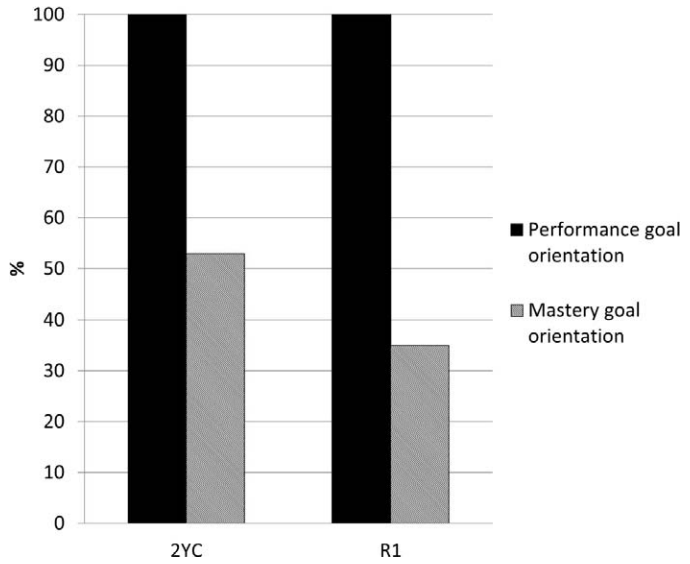

FIGURE 4: Percent of R1 and 2YC participants who reported performance and mastery goal orientations.

geology course resulted. While participants were unavailable to review and confirm the validity of final codes (member checks), participants reviewed and confirmed the interviewer's field notes (Phase 1 in Fig. 2), establishing the validity of any interpretations or conclusions that closely follow the wording or sentiment of the field notes.

RESULTS

The overarching themes that emerged from the data included the achievement goal orientation of the student (consistent with performance and mastery goal orientations already identified in the literature) and the emotional goals of the student (engaging in studying with the goal of avoiding or approaching emotional states).

Achievement Goal Orientation

All of the students reported some form of performance goal orientation in which they view the task is a means to an end, such as an extrinsic reward like a grade, degree, or job (see Table I, Code 1). Mastery goal orientation, in which they see the task as an end unto itself, such as desire to learn, interest, future use, etc. was reported by 43% of participants (18 students; see Table I, Code 2). When the data were sorted into high performing (earned A or B average on exams) and low performing (earned an average of C or below on exams) subpopulations, 70% (14 of 20) of high performers and 18% (4 of 22) low performers reported a mastery goal orientation (Fig. 3). When data were examined as 2YC and R1 university subpopulations, 53% (10 of 19) 2YC students and 35% (8 of 23) R1 university students reported aspects of mastery goal orientation (Fig. 4).

Emotion

Eighty-one percent (34 of 42) of all students included emotion as part of their explanation of what motivated them to prepare for an exam (Table I, Codes 3 and 4). This majority was consistent across gender (74% of males and 87% of females). These students can be further separated into subgroups: 29% (12 of 42) reported avoiding negative emotions; 19% (8 of 42) reported approaching positive emotions only; and 33% (14 of 42) described both avoiding negative emotions and approaching positive emotions. High performing students were more likely to report they were avoiding negative emotions (80%; 16 of 20) than low performing students (46%; 10 of 22; Fig. 5). This majority of high performers was consistent across gender (90% of females and 67% of males). Within the high performer population, 100% of students who earned an A average on exams/quizzes reported that they were avoiding negative emotion. A majority of high performers (60%; 12 of 20) and almost half of low performers (46%; 10 of 22) reported they were seeking positive emotions. This majority was inconsistent across gender (73% of high performing females and 44% of high performing males). Large majorities of both 2YC (95%; 18 of 19) and R1 students (70%; 16 of 23) reported emotional components to their motivation. Students were more likely to report avoiding negative emotions than approaching positive emotions at both types of institution (Fig. 6). In each case, a larger proportion of 2YC students (compared to university students) noted they were avoiding negative emotions (79% vs. 48%) or approaching positive emotions (63% vs. 43%).

DISCUSSION

Performance vs. Mastery Goal Orientations

The data from this study provide a unique perspective on goal orientations because, unlike other studies that rely on survey data, goal orientations emerged from the student narratives, rather than the students evaluating themselves on pre-established statements of goal orientation. Most survey-based studies focus on the correlation of these high/low average performance and mastery goal orientation scores with other factors (e.g., learning strategies). Such studies are focused on the degree to which a student expresses performance and mastery goal orientations rather than

TABLE I: Codebook: Motivation to Study.

Code	Definition	Subcode	Description	Examples
1. Performance goal orientation	"[E]ngaging in a learning task is the means to an end. The main concern the student has is related to issues that are not directly related to participating in the task itself (such as grades, rewards, comparing one's performance to that of others)" (Pintrich et al., 1991, 9; MSLQ manual).	1.1 Grade reward	Student engages to earn a "good" grade, to pass the class, or to improve GPA.	"Because I want to have a good GPA." Shawn [G2]
		1.2 Future reward	Student engages because the results will result in earning a degree, graduation, transfer to another school or program, entrance to graduate school, an internship, or a job.	"[G]et a good grade and be able to pass the course so I can get a good job." Annabelle [N2]
		1.3 Secure resources	Student engages because the results will allow them to keep financial aid resources.	"Well, since I am an athlete, I have to make a certain grade point average to stay at the university." Gina [G2]
2. Mastery goal orientation	"[C]oncerns the degree to which the student perceived herself to be participating in a task for reasons such as challenge, curiosity, mastery. Having an intrinsic goal orientation towards an academic task indicates that the student's participation in the task is an end all to itself, rather than participation being a means to an end" (Pintrich et al., 1991, 10; MSLQ manual).	2.1 Desire to learn	Student engages because they want to learn something and/or value the process of learning.	"Then I realized as I came to college that I really just want to learn for myself and do well for myself." Megan [G2]
		2.2 Interest in topic	Student engages because they are curious or have an interest in the topic.	"I particularly have recently found an appreciation for natural sciences because it's the laws of the natural world we live in I think it's very, it particularly strikes a chord with me and I find it fascinating." Travis [H3]
		2.3 Mastery for future use	Student engages because they value the skills/content they are learning to understand it so that they will be able to use in the future.	"[C]lasses such as like geology or, you know, my major classes like thermodynamics and stuff, I'll, I try really hard because I want to have that understanding that I may need in the future." Jason [N2]
		2.4 Mastery for contributing to society	Student engages because the process of engagement helps society improve.	"The most helpful you can be is to be good at what you are doing. Like if you go through college and get Cs in everything, you still get a degree, but you're still the least helpful person on the team . . . you won't help to solve the problem because you don't know enough." Katrina [G2]
3. Avoid negative (activating) emotion	Students explicitly indicate a desire to reduce or avoid negative emotions as a result of their engagement.	3.1 Anxiety	Is about prospective fear of performance.	"I need to prep for tests or I'll just freak out." Hannah [G2]
		3.2 Guilt	Is about having done something for which one may deserve consequences (retrospective).	"I'm paying to come here, so I might as well make good grades." Vanessa [S2]
		3.3 Shame	Is about believing one is flawed and therefore unworthy of social acceptance and belonging.	"[T]he pressure of graduating, getting good grades . . . [from] myself and parents and seeing other students like brothers and sisters getting top honors." Sal [B2]

TABLE I: continued.

Code	Definition	Subcode	Description	Examples
		3.4 Self-disappointment	Is about believing that one has not lived up to potential.	"[F]ear of failure . . . I want to be back in the realm of intellectual intelligence . . . it's just demoralizing." Valarie [N2]
		3.5 General	Is about avoiding a negative emotion, but it is unclear which one.	"[T]hat was a dark time . . . [now] it's I have to! . . . That's my personal goal." Randy [H3]
4. Seek positive (activating) emotion	Students explicitly discuss a desire to feel a positive emotion as a result of their engagement.	4.1 Pride from achievement	Is about believing one is worthy in this case because of accomplishment in performance.	"It feels good to achieve a goal of seeing an A on a report card." Patrick [N2]
		4.2 Pride from doing a task well	Is about believing one is worthy, in this case because of accomplishment in process (putting in full effort, doing it well).	"It's a commitment. If it's worth my time and effort, I should put my best effort forward. . . . If I'm going to do something, I'm going to do it well." Travis [H3]
		4.3 Joy from fun	Is about having a pleasant experience.	"It's a fun thing to do too." Tina [H3]

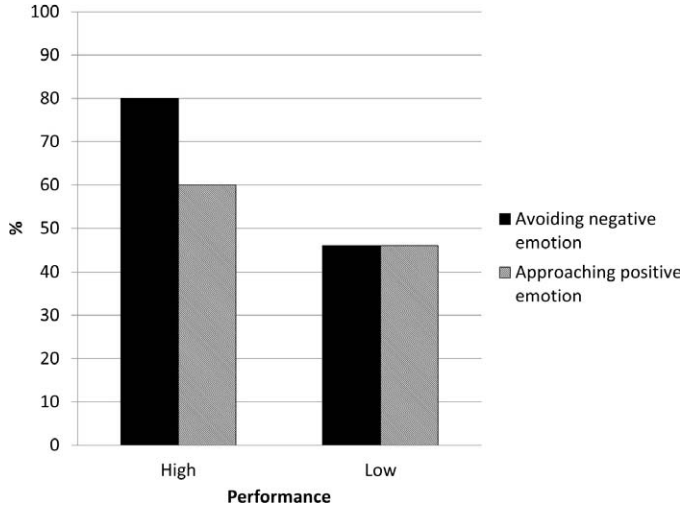

FIGURE 5: Percent of high and low performers who report they are motivated to avoid negative emotions (e.g., anxiety, shame, guilt, self-disappointment). Percent of high and low performers that report they are motivated to approach positive emotions (e.g., pride, joy) are also illustrated.

whether or not he or she expresses one or the other. By asking students to discuss what they see as important, we can reduce the tendency for researchers to preferentially select data that confirms their pre-existing beliefs (commonly called confirmation bias; Nickerson, 1998). This allows us to gain insights into whether students self-identify with one or both of the goal orientations. All students reported a performance goal orientation at the task level when preparing for an exam, with fewer reporting a mastery goal orientation. While students may identify with mastery goal orientations at a more global course level (see Gilbert et al., 2012), at the task level, performance goal orientation dominates their engagement. The nature of the course assessment therefore appears to drive their focus, and thus their actions and learning gains.

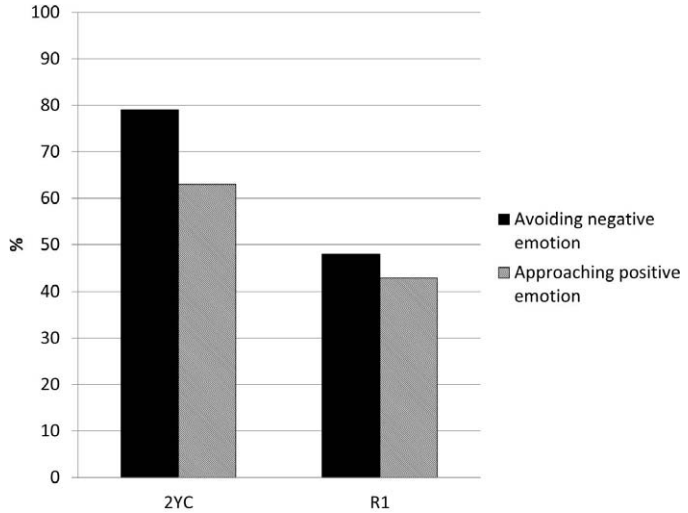

FIGURE 6: Percent of R1 and 2YC students who reported avoiding negative emotions and approaching positive emotions.

Mastery goal orientation has been correlated with higher performance and the more effective use of self-regulated learning strategies. Self-regulated learning is "an active, constructive process whereby learners set goals for their learning and then attempt to monitor, regulate, and control their cognition, motivation, and behavior, guided and constrained by their goals and the contextual features in the environment" (Pintrich, 2000a, 453). The absence of a mastery orientation in most students could be interpreted to represent a corresponding deficit of self-regulated learning strategies in preparation for an exam. When we examine performance, we see that our results are consistent with the dominant literature indicating that high performance levels correlate with mastery goal orientation (see comprehensive review of this correlation in Meece et al., 2006).

Another advantage to using qualitative grounded theory methodology is that we can observe how students interpret questions about their motivation in terms of goal level. Surveys like the MSLQ, are assumed to represent course-level motivation, but actually ask students to consider multiple goal levels through prompts such as "in this class," "when I take a test," and "for this course." In this study, we explicitly asked students to discuss what motivated them to do the tasks they described in preparing for an exam (task-level motivation). Despite this clear task-level prompt, most student responses revealed a more complex relationship between goal levels. For example, Cassandra (a R1 student) declares that she motivates herself to use flashcards to prepare for an exam because she wants a good grade in the class (course-level). The implication is that getting a good grade on the exam (task-level) will result in a good grade in the class. When she is prompted about why she wants a good grade, she connects to more global goals such as GPA and being able to transfer into a specific program in the college (school-goal) which is linked to her broader career goals. Such data suggests students are toggling between goal levels and/or framing their task-level motivation in more global school and life goals. If we examine the codebook that emerged from student responses (Table I), we see that most instances of mastery orientation are more global in nature, while performance orientation tends to be at the task level with connections to more global goals. This apparent mixing of goal levels may be actually be evidence of a future time perspective theory which focuses on the connection between beliefs and motivation (Husman and Shell, 2008). More studies establishing a clear link between student strategies and their future goals are needed to clarify these relationships.

Motivation–Emotion Connections

Most students (81%) report an emotion component when they reflect on their motivation to prepare for an exam, suggesting that emotion plays a significant role in achievement motivation. Most emotion–achievement models predict that positive emotions (e.g., joy, pride) would be indicated by students who report higher levels of mastery goal orientation and negative emotions (e.g., shame, guilt) would be associated with performance-avoidance goal orientations. We do see some support of this in our results. For example, Faith says "If I get an A on the test I'd be like, "Oh I want to get an A on the next test too." I think it actually motivates me rather than getting a bad test. Not saying a bad test does not make me want to do better but . . . an extra motivat[or] I think if I receive a good grade first." Faith wants to sustain the pride she is feeling and uses that emotion to drive her to action.

Unlike the predictions of most emotion–achievement models, our results show a high incidence of the avoidance of negative emotions by students who report mastery goal orientation. Some students appear to be using feelings of guilt and shame to engage in learning strategies. For example, Vanessa (R1) states she is "paying to come here, so [she] might as well make good grades . . . [she's] capable of doing so, so why be lazy?" There is a sense of guilt for potentially wasting both money and her ability by doing poorly. By including laziness, she also equates effort/action with performance (good grades). She uses this emotionally charged self-talk and self-instruction as a way to motivate and regulate her engagement. In this sense, Vanessa uses the anticipation of emotional responses to drive her to action. This is in direct contrast with model predictions and responses from other students like Faith (R1) who use retrospective emotions to drive action. This unexpected result suggests we need to examine how students are using emotions to engage in learning strategies.

High Performing Students vs. Low Performing Students

A clear majority (70%) of high performers (those who earn an A or B average on their exams in the class) report a mastery goal orientation in addition to their performance orientation compared to only 18% of low performers (those who earn a C average or below on their exams). If we separate the high performers even further, we find that 100% of those students who earned an A average on exams indicated a mastery goal orientation in addition to their performance goal orientation. These high performing students (both A and B averages) are motivated by their interest in the topic, learning in general, or how their learning process contributes to improving society in general. As Patrick, a R1 university student (STEM major) put it, "I was really intrigued by it." He went on to explain that he put the effort and time into applying his study methods because he had an insatiable curiosity about the world. He didn't want to just be able to repeat the answers the instructor was looking for, he wanted to understand why the answer was the way it was. While it seems logical that a geoscience or STEM major is motivated by mastery goals such as interest and value, it is important to note that 30% of the high performers are not geoscience or STEM majors. Non-STEM related majors such as Staci (an arts major at a R1 university) echoed such curiosity as an inherent task value, indicating that she "would like to get the most as possible" out of her learning experience in class, viewing preparation for an exam as one of those tasks. Note the more global nature of her mastery orientation. This suggests that there may be a relationship between complex goal level patterns and performance.

If we examine the nature of these mastery goal orientations of high performing students, we can see that mastery goals correspond with deeper learning strategies such as elaboration (e.g., paraphrasing, creating analogies) and/or organization (e.g., creating outlines or concept maps). For example, if a student is driven to understand the "why" behind a concept, they will relate new concepts to pre-existing knowledge and find analogies and resources to

construct new conceptual meaning. In this way, these results are consistent with previous reports that suggest that high performers are more intrinsically motivated individuals who value a task as a process in addition to the benefits of completing a task successfully (Pintrich, 2000b).

But what of the low performers that indicated mastery goal orientations in addition to their performance goal orientation? Why were they not as successful? When we examine the student reflections on their motivation in the context of the geology study strategies they outlined during the interview, a clear distinction emerges between the high performing and low performing mastery-goal-oriented students: a disconnect between their motivation and action. In other words, the sources students perceive as motivation to study action aren't actually resulting in study action. For example, Andre (a 2YC student), indicates an interest in geology as part of his motivation early in the interview, but goes on to explain that "like it's motivation of I want to do the stuff I like to do after, I basically say I have to do the work first" When it comes down to the motivation behind his actual study actions, he is purely motivated by extrinsic rewards (getting to do what he really wants to do). Andre's study strategies (chunking his time 1–2 days before a summative assessment by quizzing himself with flashcards containing general key concepts) focus on rehearsal strategies rather than elaboration and do little to satisfy his purported interest in geology. When we compare this to Patrick's interest from earlier, we see that unlike Andre, Patrick's interest and curiosity coincide with how Patrick studies. Unlike Andre, Patrick uses his curiosity to drive his effort levels and persistence at a study task: "[he's] going to do this however long it takes."

It is possible that the low performing mastery-goal-oriented students are inaccurate in their self-monitoring or are projecting an ideal version of themselves to the interviewer. Graham (a 2YC student in his seventh semester) indicates that "just learning is awesome," but he also acknowledges that for geology, for some inexplicable (to him) reason he just "isn't doing anything [to study] for [geology]." While he is self-reflective in his interview, unlike the high performing students, he has failed to fully evaluate his self-observations. He has yet to determine why he is motivated or not motivated to action and more importantly, he fails to enact strategies to regulate his motivation even when he recognizes that it is failing him. From these conflicting results, we can see that student self-report data on survey instruments measuring course level motivation can miss how motivation actually mediates student learning processes and outcomes at the task level. A student, like Graham, may indicate a mastery goal orientation when reflecting on their motivation to engage in a task such as studying for an exam, but describe a performance goal orientation behind their actual study action.

The majority of high performers indicate discrete emotions (e.g., anxiety, guilt, self-disappointment, pride). If we further sort the A high performers from the B high performers, we see that all A students report they are avoiding negative emotions. We propose that this is evidence that high performers use emotions as motivational controls to regulate their engagement in self-regulated studying activities. Consider what Travis (2YC) tells us: "if that's what I decided to do, then I'm going to give it my best efforts, otherwise it is a waste of time." He will engage in his study strategies with clear purpose and high effort levels to avoid feeling guilt at wasting time. The conviction in his voice and his description of his study methods in another part of the interview appear in support of his claim of avoiding guilt.

When we examine the high and low performing populations in general, we observe that 2YC students are 35% of the high performing population and 59% of the low performing population. This appears to be related to the grade portfolio breakdown of 2YC courses. They tend to have less of the final course grade determined by performance on summative assessments (e.g., exams) than the R1 courses. When we further examine the high performing students who indicate an additional mastery goal orientation, we see that half of these high performers with mastery goal orientation are from 2YC. In contrast, it is of interest to note that all (except one) of the low performing students with mastery goal orientation were 2YC students. This brings to light the question of differences in motivational needs and processes between the R1 and 2YC populations.

R1 Universities vs. Two-Year Colleges

On first glance, R1 and 2YC appear similar in that all students report performance goal orientation and fewer students indicate mastery goal orientation. Upon closer examination, we see that a higher percentage of 2YC students report a mastery goal orientation compared to R1 students. We also see that a higher percentage of 2YC students report an emotional component to their motivation, suggesting that 2YC students do in fact have higher affective loads and potential affective obstacles to their learning. Several 2YC students described their motivation with more emotional urgency due to personal context than university students with comments like "I'm picking my college career off the ground . . . that was a dark time" (Randy, 2YC). Consider Sienna, she studies to perform well "to make [her] dad proud," which by itself is perhaps unremarkable, but she follows with "making him proud is always hard," adding a deeper emotional tone evoking questions of self-esteem to this need for external validation. Additionally, she also indicates she is studying to perform well so she could someday "figure out and prevent other people" from having the same geologically related health concern her mother had. If she fails, she faces rejection from her father and a sense of guilt and shame for not metaphorically helping her mother. In other words, there is a lot more emotionally riding on her performance than is expressed by the typical R1 student, like Jason, who tries really hard in geology to perform well because he "want[s] to have that understanding that [he] may need in the future [for his career plans]." All three (Randy, Jason, and Sienna) want to perform well and they both want to use the geology content understanding for their future career plans, but Sienna has several emotional components to her motivation portrait. This high affective load (emotional demands on brain processing) has the potential to interfere with her intentions because she is focused on her feelings instead of the cognitive task itself.

Implications for Future Investigations and Improving Student Motivation

The results of this study suggest caution should be used when interpreting course level motivation survey or interview

data, as students may conflate their more global course level motivation with their task level motivation sources or express relationships between them that are difficult to parse out. By giving students a specific scenario in their course to reflect on when discussing their motivation to study for an exam (e.g., "Walk me through a typical week or two before an exam, how do you prepare?"), the responses are more likely to be a valid representation of what students actually do in geology class, rather than a global interpretation of "studying" in general. In other words, this specificity reduces the number of potential memory data points a participant is referencing when formulating their responses. They are primed to think about geology class and not math class, for example. If students digressed into how they studied for other courses, they were redirected and asked about other courses and learning in general near the end of the interview.

This study examines student motivation for the task of studying for an exam. Other tasks, such as note taking, clicker questions, small group work, class discussions, and active listening may involve different motivation. These tasks need to be explicitly examined in a similar manner to identify what motivates students to engage in different task-specific learning processes in these different tasks and to delineate where motivational processes break down for students to facilitate instructor intervention. If students are inaccurately identifying their task level motivation, a strategy for instructors could be to include opportunities for students to reflect on their learning and study strategies, including motivation. For example, instructors can ask students to set goals for the course at the start of the semester and write out exam preparation plans that connect their personal task level goals with their more global semester goals.

The results suggest that most students have a high affective load (emotional demands on brain processing). The results also suggest that high performing students use this high affective load to drive their engagement in learning processes. While it is tempting to portray the results as implying that instructors should intervene to increase or decrease student affective load, we argue the results instead suggest instructors should focus their efforts on preparing class materials and reference materials to be aligned with class assessments so that when students are motivated to engage, they have effective resources that will efficiently lead them to success. All students exhibit a performance orientation and most have emotional drives that motivate them to prepare for exams. Our job as instructors should be to clarify the processes necessary for success on exams. For example, by providing explicit learning objectives that are tied to the assessments, students can focus their efforts on strategies to learn the concepts rather than trying to figure out what they need to learn.

Limitations

The strength of this study lies in using the student voice to characterize a model for motivation and emotion, rather than asking students how they compare to an existing model for motivation. However, even when students are explicitly asked about their task level goals, they frequently discuss them in terms of more global goals. This tendency to discuss multiple goals and levels simultaneously presents a challenge for anyone seeking to account for the principle mediators of student outcomes. Future studies could include follow up questions in the interview protocol that explicitly prompt students to differentiate between the task level and global level more accurately to establish the relative significance of each.

While the participant population demographics of this population were consistent with the larger study population (see Methods section), the participant population selection process presents a few noteworthy limitations to consider. First, participants were limited to R1 and 2YC institutions. Future studies could include other populations such as private liberal arts colleges. Second, participants were volunteers and were offered a $20 gift card for participating. Such incentives (financial and social) potentially bias the sample towards individuals that have similar motivations for participating like the goal of getting a gift card. While a few participants divulged post interview that they were motivated primarily by the gift card, the majority of participants indicated they were interested in sharing their experience in geology. The average time of the interviews (~45 minutes) suggests that the majority of participants were genuinely considering the questions, rather than rushing through to get done. Third, the sample population of this study reported disproportionately higher levels of interest in science compared to the larger study population. However, like the larger population, participants were predominately non-STEM majors. Finally, the majority of the participant population earned an A or B in the course, suggesting there may be some unaccounted for motivation bias in our population selection. We reduced this bias, however, by using exam grade averages in lieu of final course grade. When these exam averages were sorted by high and low performance, the population was no longer skewed towards high performers. While it would have been more ideal to select a population randomly from the larger study or, in keeping with grounded theory methods, select a population based on emerging ideas, it wasn't practical due to the logistical requirements of one researchers interviewing participants at multiple institutions across the U.S. For example, limited funding only allowed the interviewer to be on campus for 2–3 days. If a student was unable to interview during that window due to their schedule, they were not included in the study. Related to this scheduling conflict is the role interview timing may have played in student responses. Institutions have similar calendar schedules, preventing the researcher to interview students at the exact same time in the semester. Every effort was made to schedule the interviews around similar points in each institution's course schedule so that students had at least two exams in geology as reference points, with one exception (see methods section). Despite the limitations discussed here, the advantages and insights from including the student voice provide new data to the discussion of student learning in the geosciences that has been previously unknown.

CONCLUSION

Through our analysis of student interviews, we present a new dataset and key findings for the geoscience community. Assessment drives student actions and learning gains. All students are motivated to study to obtain extrinsic rewards (e.g., grade, degree) and the tasks that determine the majority of grade (often exams) will likely drive student focus and action. The majority of students describe an emotional component to their motivation. Course structure can be used as a tool by students to reach emotional goals

that are tied to performance. Therefore, modifying course structure to provide students with opportunities that explicitly model the processes necessary to be successful on an exam is likely to be beneficial to student outcomes.

Students indicate that mastery goal orientations in addition to performance goal orientations mediate higher performance outcomes (A or B average on exams). As mastery goal orientations are related to study strategy use (Pintrich, 2000a; Pintrich, 2000b; Elliot et al., 2011), instructors should encourage the development of student mastery goals. This can be accomplished by directing student attention to learning objectives, aligning assessments with objectives, assessing students using evaluation/analysis level questions (that require deeper study strategies), explicitly describing study strategies, and providing opportunities for students to reflect and self-evaluate performance and strategies.

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